

CLAIMS

What is claimed is:

- 1 1. An apparatus comprising:
 - 2 an electronics chip having a substrate with a first face thereof having
 - 3 circuitry thereon, and an opposite second face; and
 - 4 one or more electro-osmotic pumps in a layer over the second face.
- 1 2. The apparatus of claim 1, wherein the electro-osmotic pumps include
2 capillary pump channels in a further layer over the second face of the electronics
3 chip.
- 1 3. The apparatus of claim 2, wherein cooling channels are formed in a further
2 layer over the second face of the electronics chip in fluid communication with the
3 electro-osmotic pumps.
- 1 4. The apparatus of claim 3, wherein external fluid connections to the pumps
2 are made at lateral edges of the apparatus.
- 1 5. The apparatus of claim 1, wherein electrical power for the electro-osmotic
2 pumps is conducted by electrical conductors formed through the electronics chip.
- 1 6. The apparatus of claim 2, wherein cooling channels are formed in a further
2 layer of material over the second face of the electronics chip, and the electro-
3 osmotic pumps are in fluid communication with the cooling channels.
- 1 7. The apparatus of claim 6, wherein external fluid connections to the pumps
2 are made at lateral edges of the apparatus.

1 8. The apparatus of claim 6, wherein electrical power for the electro-osmotic
2 pumps is conducted by electrical conductors through the electronics chip to the
3 pumps.

1 9. The apparatus of claim 1, wherein the cooling channels are formed in the
2 same layer as the capillary pump channels.

1 10. The apparatus of claim 1, wherein the electronics chip is silicon, cooling
2 channels are formed in a layer of silicon over the second face of the electronics chip,
3 and the electro-osmotic pumps are formed in a further layer of silicon over the
4 second face of the silicon chip in fluid communication with the cooling channels.

1 11. The apparatus of claim 10, wherein external fluid connections are made at
2 lateral edges of the apparatus.

1 12. The apparatus of claim 10, wherein electrical power for the electro-osmotic
2 pumps is conducted by electrical conductors formed through the electronics chip.

1 13. The apparatus of claim 1, wherein the chip is made of silicon, and the
2 electro-osmotic pumps include capillary pump channels formed in a layer of silicon
3 over the second face of the chip.

1 14. The apparatus of claim 1, wherein the chip includes circuitry for at least a
2 portion of a processor, the apparatus further comprising:
3 a memory operatively coupled to the processor;
4 an input/output system, including a display unit, operatively coupled to the
5 processor; and
6 a power supply operatively coupled to the processor.

1 15. The apparatus of claim 1, wherein the chip includes circuitry for at least a
2 portion of a telecommunications circuit, the apparatus further comprising:
3 an antenna operatively coupled to the telecommunications circuit;
4 an input/output system, including a display unit, operatively coupled to the
5 telecommunications circuit; and
6 a power supply operatively coupled to the telecommunications circuit.

1 16. A method for cooling an electronics chip on a substrate with a first face
2 thereof having circuitry thereon, and an opposite second face, the method
3 comprising:

4 pumping a cooling fluid thermally coupled to the second face with one or
5 more electro-osmotic pumps positioned over the second face.

1 17. The method of claim 16, wherein the electro-osmotic pumps include
2 capillary channels in a layer of material over the second face of the electronics chip,
3 and wherein the pumping includes electroosmotically flowing the cooling fluid in
4 the capillary channels.

1 18. The method of claim 16, further comprising:
2 flowing the cooling fluid through external fluid connections at lateral edges
3 of the electronics chip and the layer containing the electro-osmotic pumps.

1 19. The method of claim 16, further comprising:
2 conducting electrical power for the electro-osmotic pumps through electrical
3 conductors passing through the electronics chip.

1 20. A method comprising:
2 providing an electronics chip having a substrate with a first face having
3 circuitry thereon, and an opposite second face; and

4 providing at least one layer of material over the second face, one of the at
5 least one layers forming at least one electro-osmotic pump.

1 21. The method of claim 20, further comprising:
2 forming cooling channels in one of the at least one layers of material over
3 the second face of the electronics chip, the channels operatively coupled to one of
4 the at least one electro-osmotic pumps.

1 22. The method of claim 21, further comprising:
2 attaching a handle layer to the first face of the electronics chip; and
3 thinning the electronics chip by polishing and/or etching the second face of
4 the electronics chip.

1 23. The method of claim 22, further comprising:
2 forming electrical conductors through the electronics chip, for supplying
3 electrical power to the electro-osmotic pumps.

1 24. The method of claim 23, wherein the chip is made of silicon, and the layer
2 silicon over the second face of the circuit die is attached to the silicon chip.

1 25. The method of claim 23, further comprising:
2 packaging the electronics chip into a package;
3 mounting the package onto a circuit board having other circuitry; and
4 coupling the packaged electronics chip to supply of fluid to the electro-
5 osmotic pump.

1 26. An apparatus comprising:
2 an electronics chip; and
3 an electro-osmotic pump for circulating cooling fluid through cooling
4 channels adjacent a face of the chip.

1 27. The apparatus of claim 26, wherein the electro-osmotic pump and the
2 cooling channel are in separate layers of material attached to the face of the chip..

1 28. The apparatus of claim 27, wherein the electro-osmotic pump and the
2 cooling channel are in the same layer of material.

1 29. The apparatus of claim 28, wherein the electro-osmotic pumping means and
2 the cooling channel are in substantially the same plane.